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# Nuclear Energy Questions and Answers

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**Answers to often-asked questions about  
radiation and nuclear power plants**

# Introduction

The Massachusetts Civil Defense Agency (MCDA) has the primary responsibility for assuring that the Commonwealth is well prepared for any disaster or emergency, and for coordinating the response to disasters when they do occur. The Massachusetts Department of Public Health (DPH) includes regulation of radioactive materials and response to radiation emergencies among its many public health responsibilities.

In December 1979, MCDA and DPH published detailed plans for responding to radiation emergencies in areas near nuclear power stations. These plans, which were developed with the willing effort of many local police, fire, civil defense and other officials, provide for prompt notification to the State of any actual or developing emergency at a nuclear power station, rapid notification of local officials and the public in areas possibly affected, and evacuation, shelter or other appropriate protective action for the public should this be necessary.

These plans also provide for periodic distribution of information such as that contained in this booklet to people living, working or traveling in the areas around nuclear power stations.

This booklet provides answers to often-asked questions about radiation in general, and nuclear power plants in particular. It was prepared with the help of many state and federal officials using the best available resources and reference materials.

This booklet takes no sides on the nuclear issue. Instead, it attempts to present the facts in clear language in the hope that readers will understand more fully nuclear energy and emergency plans for responding to any radiation accident.

## What is a nuclear power plant?

It is a power plant that produces electricity from nuclear energy. In a nuclear power plant, uranium is used to produce heat and, ultimately, electricity. The uranium atoms split (fission) creating the heat which turns water into usable steam. The steam turns a turbine, which turns a generator producing electricity. (In a conventional power plant, coal or oil is the fuel source used to create steam which then turns the turbine-generator just as in a nuclear plant.) Physically, hundreds of metal tubes encase the nuclear plant's uranium. The tubes are about  $\frac{1}{2}$  inch in diameter and about 12 feet long. The uranium itself is formed into pellets—each about  $\frac{1}{2}$  inch long—before being placed into these tubes. The tubes are then formed in fuel bundles of about 50 to 100 tubes each. Several hundred bundles are enclosed in an air-tight pressure (reactor) vessel generally made of six-inch thick steel. The steel vessel is surrounded by a five to six-foot thick reinforced concrete containment structure. The reactor is filled with water, which is needed both to cool the fuel and to maintain the fission chain reaction.

Modern nuclear power plants are very large. A typical plant has an electrical capacity of 1,000,000 kilowatts, or 1,000 megawatts. This is enough electricity for about 750,000 average homes.

## **Can a nuclear power plant explode like an atom bomb?**

No. It is impossible for nuclear power plants to explode like a nuclear weapon because they contain only a small fraction (3 to 5 percent) of the concentration of a special type of uranium (uranium 235) that is used in weapons. A nuclear power plant is designed to maintain a controlled nuclear reaction. Many systems within the plant help assure the plant's safe operation. These systems have additional back-up systems (mechanically or manually operated), all of which are designed to stop an unsafe condition that may have occurred.

This whole series of safety features is designed to protect operators and the public against a wide range of possible accidents from the very small to the very serious—a loss of coolant accident which might melt the nuclear fuel and cause a radioactive release. For this to happen, all of the reactor's emergency cooling water supply systems must fail. If the fuel does melt, however, the containment structure surrounding the reactor is designed to contain the radioactive gases and any particulate matter released from the reactor vessel.

The most serious core melt accident followed by containment failure would pose a wide range of consequences depending upon the radioactive material content of the fuel, the amount and rate of radioactivity released, the way it is dispersed, and the number of people exposed to the radiation. Emergency plans for the plant site and for the area in the general vicinity of the plant are designed to minimize public exposure to radiation.

## **What are the consequences of serious reactor accidents?**

There is a possibility of injury and/or increased risk of health effects. However, most reactor accidents, including most core melt accidents, would not result in any immediate or short-term injuries or fatalities to the public. Fatalities over the long-term among a very large population would in most cases be less than one.

For less likely but more serious core melt accidents followed by a large-scale atmospheric release, a wide range of consequences is possible depending upon the amount and rate of radioactivity released, the way it is dispersed by the prevailing weather conditions and the number of people exposed to the radiation. These consequences can include fatalities and injuries in areas close to the plant, and increases in cancers and genetic effects in more distant areas. An accident of this severity is extremely low in probability—less than once per 100,000 years for each nuclear plant.

## **How great are the risks associated with nuclear power plants?**

A study commissioned by the U.S. Nuclear Regulatory Commission\* concluded that the likelihood of death or injury from nuclear reactor accidents is much smaller than that of many non-nuclear accidents having similar consequences, including fires, explosions, toxic chemical releases, dam failure, airplane crashes and various natural disasters.

The study states that from the viewpoint of a person living in the general vicinity of a reactor, the likelihood of being killed in any one year in a reactor accident is one chance in five billion, and the likelihood of being injured is one chance in 75 million.

By contrast, the likelihood of any one individual being killed in an auto accident is one in 4,000 and of being injured in an auto accident, one in 130.

While the error bounds on these estimates are quite high and should not be used uncritically, the estimates are the best available.

*\*Reactor Safety Study—An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, United States Nuclear Regulatory Commission, October 1975*

## What is radiation?

Radiation is simply energy; specifically, energy in motion. Although the term *radiation* is broad and includes such things as light, heat and radio waves, it is often used to mean *ionizing* radiation. This is radiation of sufficient energy to produce charged particles (ions) in materials. Thus, ionizing radiation can produce physical and biological changes in matter. For this reason, in plant operation, exposure to radiation is controlled and regulated to what are considered safe working levels.

There are various types of ionizing radiation: alpha, beta, gamma, x-rays and neutrons, each with different characteristics. Atoms that emit these kinds of radiation are called *radioactive atoms* and are the source of radiation from a nuclear plant.

The principal types of radiation that are of concern outside the reactor itself are beta (short range) and gamma (long range) radiation. The principal techniques applied to protect against radiation are shielding, distance and reducing duration of exposure.

## How do you measure radiation?

The biological unit of measurement of radiation exposure is called the *rem*. However, people generally use a smaller unit, the *millirem*, which is 1/1,000 of a rem. Although we can't see, taste or smell radiation, it can be easily detected even in miniscule amounts with instruments such as geiger counters.

Radiation is not mysterious. It is a well understood physical phenomenon. We live in an environment of natural radiation exposure. People living near sea level ordinarily receive an annual exposure of about 100 to 125 millirem from natural sources. Scientific assessments have not shown any harmful effects from such low levels of radiation.

## What are the regulatory limits for nuclear power plant emissions?

The United States Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA) have set limits on the amounts of radioactive material which can be discharged into the environment. EPA regulations limit the amount of exposure to any member of the public to not more than 25 millirem per year from the fuel cycle activities associated with the operation of a nuclear power plant. In addition, NRC design objective limits on nuclear power plant effluents call for an allowable limit of 5 millirem per year to any person at the site boundary. Actual exposures at the boundary of a nuclear plant are in the range of one to two millirem per year.

## What is the risk associated with radiation exposure?

Scientists use what is called the *linear response no threshold hypothesis* to estimate the risk of radiation effects. Simply put, this means that any radiation exposure is accompanied by some risk. Although there is some disagreement in this area, authoritative groups, such as the Biological Effects of Ionizing Radiation (BEIR) Committee of the National Academy of Sciences, feel that the linear response no threshold hypothesis is a useful risk assessment and standard setting tool which probably overestimates low-level radiation effects.

At low levels, exposure to radiation does not always result in a certain effect but rather increases the probability or risk of that effect.

The degree of risk associated with exposure to low-level radiation is very small, but scientifically cannot be stated to be zero. Any risk from radiation-related activities must be balanced against the benefits gained and the risks of alternative activities. Medical use of radiation, for example, has great benefits in the detection and treatment of disease. And, yet, the average annual radiation exposure per person in the United States from medical diagnostics is 85 millirem.

## **Why an emergency plan at all?**

Emergency plans are required and make sense. The Nuclear Regulatory Commission, in its regulations concerning emergency plans for nuclear power reactors, states: "No operating license for a nuclear power reactor will be issued unless a finding is made by the NRC that the state of onsite and offsite emergency preparedness provides reasonable assurances that adequate protective measures can and will be taken in the event of a radiological emergency."

Nuclear power plants are not unique in having an emergency plan as part of normal operations. Many industries—oil, chemical and transportation among them—require such plans. Emergency plans help assure that appropriate protective actions are taken on behalf of the public and, therefore, reduce risks. The Nuclear Regulatory Commission further requires that the plant's emergency plan be reviewed each year and that drills are conducted yearly as well. Federal, state and local officials are notified of these drills and participate in them. The plan itself is a living document that is modified as necessary to insure its effectiveness in providing for maximum public safety.

## **How will I know there has been an accident?**

In Massachusetts, each nuclear power station is linked by a communications system to the State Police. When notified of an actual or potential emergency, the State Police immediately notify the Massachusetts Department of Public Health and utilize the National Attack Warning System and law enforcement communications networks to alert Civil Defense and local officials. Based on assessments made by Department of Public Health radiation specialists, the Governor or the Commissioner of Public Health will recommend a course of action to local police, fire and other officials through the state civil defense network.

Should evacuation, shelter or other action be necessary, you will be alerted several ways:

- Town Civil Defense sirens—three-to-five minutes steady wail;
- Tone-alert radios in buildings where these have been placed;
- Police or other official vehicles with mobile public address systems on a street-by-street basis;
- Local television and radio stations.

When you hear any of these warnings, take shelter indoors and turn on your radio or television to a local station.

# What action should I take?

## If you are directed to take shelter:

1. Go indoors and close all doors and windows. *Do not evacuate*; this may expose you to more radiation than staying inside.
2. Go to the lowest and most central rooms in your house—locations without windows and outside doors.
3. Turn off all air conditioners and fans.
4. Remain indoors until notified otherwise.
5. Do not use the telephone except for emergency.
6. Keep your radio or TV on for information.
7. Food and water in your home is safe.
8. Do not eat garden produce after shelter period.

## If you are directed to evacuate:

1. Turn off all appliances.
2. Take extra clothing, blankets and personal necessities.
3. Secure your property as if you were going on vacation.
4. Keep vehicle windows and vents closed and the radio tuned to emergency stations.
5. Follow *evacuation route markers*!
6. Obey speed limits and traffic directions.

## Special attention for farm families:

7. Get livestock under cover if possible.
8. Provide stored feed and water.
9. Secure farm buildings.

**Note:** Cattle feed, freshly harvested vegetables, open water supplies and soil can be contaminated by particulates or by rain passing through a radioactive plume. If contaminated, fresh vegetables, cattle feed, milk from grazing cattle and water from exposed reservoirs must be tested before consumption. Food and water in the home prior to the emergency are safe.

Once the emergency is over and state officials determine that it is safe to return to the evacuated area, an announcement to that effect will be made over major area stations.

## Keep emergency items on hand:

1. Flashlight with extra batteries.
2. Portable radio with extra batteries.
3. First aid kit.
4. Tools or tool kit.
5. Concentrated foods.

## Factors to remember:

- An accident at a nuclear plant serious enough to require evacuation is highly unlikely.
- The plant will not explode like an atomic bomb.
- The amount of radiation released that might call for an evacuation of an area near the plant is small in terms of the level that would be expected to cause serious health effects.
- Ample time will be available for an orderly evacuation without exposing the residents to large amounts of radiation.

## How large an area may be affected?

The federal Nuclear Regulatory Commission and the Environmental Protection Agency recommend an Emergency Planning Zone (EPZ) of about ten miles around each nuclear power station as a plume exposure planning zone. They recommend that plans for protective action, including evacuation and sheltering, be developed for that area. The Massachusetts legislature passed a law in 1979 which mandates that plans for evacuation and other protective actions be developed for all areas within a ten-mile radius of each nuclear power station in Massachusetts.

The ten-mile radius was chosen because, for serious reactor accidents including a core melt, evacuation, shelter or access control would not generally be recommended beyond ten miles. Contamination of farm produce, dairy feed and water supplies is possible over greater distances. To address this, the Nuclear Regulatory Commission and the Environmental Protection Agency recommend that ingestion exposure protective actions could be necessary as far as 50 miles from a nuclear power station, including removing cattle from pasture and testing and removing contaminated produce and milk from the market.

Massachusetts' plans provide for carrying out these ingestion exposure protective actions anywhere in the state, depending upon wind direction at the time of a release.

## **For additional information**

### **Concerning radiation, call or write:**

Massachusetts Department of Public Health  
Radiation Control Program, Room 770  
600 Washington Street  
Boston, MA 02111

or

Massachusetts Department of Public Health  
Radiation Control Program  
Western Massachusetts Public Health Center  
University of Massachusetts  
Amherst, MA 01003

### **Concerning the emergency plan, call or write:**

your local civil defense director

or

Massachusetts Civil Defense Agency  
400 Worcester Road  
Framingham, MA 01701



**Massachusetts Department  
of Public Health**

**Massachusetts Civil  
Defense Agency,  
Office of Emergency  
Preparedness**